Ecology: Along the streams in forests, rare.

Flowering: October - January.

Distribution: India: Andhra Pradesh, Assam, Konkan, U.P., Bengal.

World: Sri Lanka, (Myanmar) Burma, Thailand.

Specimens examined: Talakona (Chittoor district), C.P. Raju 13245.

Adenostemma lavenia (L.) O. Ktze. var. *madurense* (DC.) Panigrahi in Kew Bull. 30 (4): 654. 1975; R.R. Rao *et al.*., Fl. Ind. Enum. - Ast. 12. 1988 *A. madurense* DC. in Wt., Contrib. Bot. Ind. 9. 1834. *A. viscosum* J.r. Forst. & J.G. Forst. var. *reticulatum* Hk. f., Fl. Brit. Ind., 3:242. 1881. pro parte.

Erect herb, 30-100 cm; stem glandular pubescent. Leaves opposite, sparsely puberulous, 2-17 x 1-11 cm, obtuse-attenuate at base, serrate-dentate, apex acute. Heads few, terminal on divaricating branches, white, 7 mm long, homogamous, not rayed; peduncle up to 2 cm, densely glandular and pubescent. Involucral bracts 13, sub-biseriate, elliptic, obovate or elliptic-oblanceolate, 4.5 - 5.5 mm, very sparsely glandular and hairy on dorsal side towards base, margin usually ciliate with glands, obtuse or minutely dentate. Receptacle alveolate, 1-2 mm across. Florets 18 - 20, corolla 3 mm long, 5-lobed; lobes ovate, 0.5 mm long, densely hairy on dorsal side, acute. Stamens 5; anthers linear-oblong, 1 mm, hood retuse at apex, base truncated to obtuse. Style 5 mm, exerted to 2.5 mm, branches 3.5 mm, broad, spathulate, obtuse. Pappus of 3 clavate scales, on a short ring, 1 mm. Achene compressed, oblanceolate, 5 mm, slightly curved, young ones yellow, matured black, minutely glandular.

Ecology: Along streams at higher elevations, rare.

Flowering: August - January.

Distribution: India: South India, Assam.

World: Malaya, Myanmar (Burma), Sri Lanka.

Specimens examined: Anantagiri (Visakhapatnam district), C.P. Raju 9959.

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37. SUN-TRACKING IN *RANUNCULUS HIRTELLUS* ROYLE EX D.DON.

(With one text-figure)

The facility with which heliotropic leaves and flowers turn to face the sun has for so long been part of nature lore that it may well be surprising to the casual observer that so little is known of the mechanism of perception and response of foliar orientation (Smith, 1984). Heliotropic movement by flowers have been described for over a century (Hooker, 1881). Kevan (1972) defined these heliotropic movements or heliotropism as the "diel bending response or turning of plants directly to and with the sun". It is now known that heliotropic movements are mediated by changes in cell turgor pressure (Vogelmann, 1984). Heliotropic movements have been studied in detail in the arctic flowers like *Dryas integrifolia, Papaver radicatum* Kevan, 1975), tropical alpine flowers like *Oritrophium limnophilum* (Smith, 1975), alpine flowers like *Ranunculus adoneus* (Stanton and Galen, 1989), in leaves of *Lavatera cretica, Malva parviflora* (Koller, 1980) etc.

Heliotropism in the flowers of alpine plants growing in the Himalayan arc have still not been noticed. The Himalayan alpine zones, similar to other alpine zones of the earth, are very cold and any biotic mechanism such as heliotropism for maximizing use of small heat budget in the form of solar radiation is

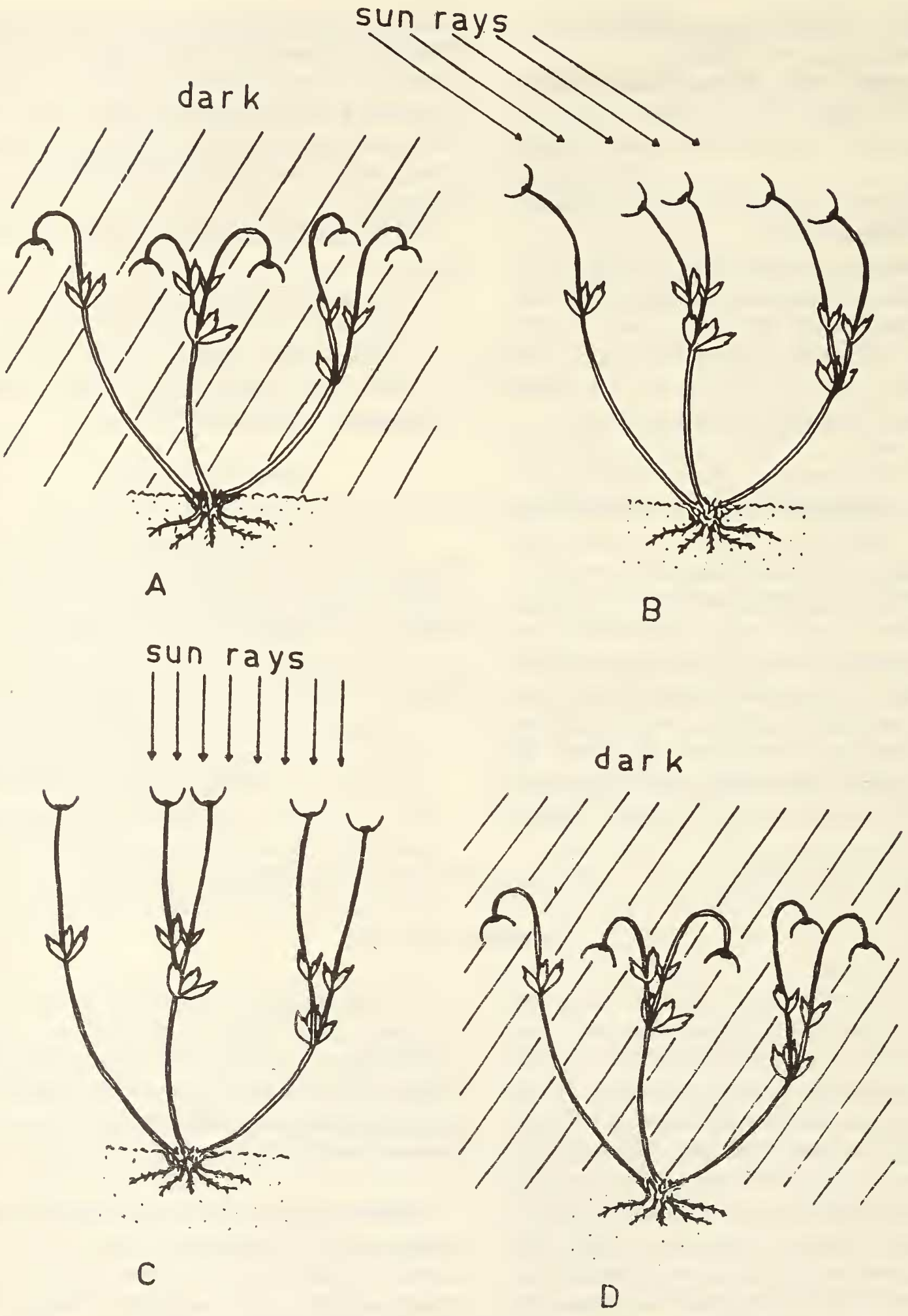

Fig. 1 General trend of heliotropism in *Ranunculus hirtellus* Royle ex D.Don
A - at 00 hrs the flowers are pendent; B - at 0008 hrs the flowers are oriented towards the suns heat; C - at 1200 hrs the flowers face the sky; D - at 2000 hrs the flowers are pendent again.

advantageous. During the third week of June, 1994 we noticed partial heliotropism in *Ranunculus hirtellus* Royle ex D.Don,. This is the first report of heliotropism in any alpine plant of the Himalaya, although the possibilities had already been indicated (Ohba, 1988).

Observations on *Ranunculus hirtellus* Royle ex D.Don revealed that this species shows sun-tracking from early morning hours to mid-afternoon. The observation site is located in the glacial valley of Kedarnath (3560 m above msl), Garhwal Himalaya, India. The valley lying in north south direction has high ridges (*c.* 5000 m) on either side with typical alpine vegetation on slopes and in the centre.

Ranunculus hirtellus is an ascending perennial herb growing early in the marshy areas near snow edges. During the days of observations, the sun rose at 0745 hrs and the sky remained clear till 1300-1400 hrs in the evening it rained or remained overcast. These environmental conditions are common in the Himalayan alpine zones during June and prevailed throughout the observation week. The flowers were shining yellow, bowl-shaped with a diameter of 1.0-1.5 cm. In our simplified observations 150 flowers of this species were randomly selected and their positions - sunfacing (S) or randomly oriented (R) were recorded at 0008 hrs 1200 hrs, 2000 hrs and 00 hrs continuously for a week. The reading at 1600 hrs were avoided as the sky remained overcast and the sun-tracking movement get discounted in cloudy sky. The results are provided in the table below:-

All 150 flowers were closely observed and it was found that the majority of the flowers moved with the sun, i.e. *c.* 15° per hour, starting their movement just before sunrise and became vertically oriented between 1200 hrs to 1300 hrs. It was also noticed that majority of the flowers remained pendent in the night. Young flowers with shining bowl-shaped petals and long slender pedicels (2-3 cm or more) are more efficient in sun-tracking than mature flowers with sepals perpendicular to floral axis and short thick pedicels. The most efficient sun-tracking flowers show about 15° turn per hour for about 4-5 hours i.e. from 0008 hrs - 1300 hrs. Unfortunately after 1300 hrs the sky usually becomes cloudy, hiding the sun and if raining (in the rain flowers become pendent) the sun-tracking is discontinued. In overcast sky orientation of the flowers was random in most of the flowers.

In a separate experiment 25 unopened flowers of *Ranunculus hirtellus* were emasculated and rest of the flowers in the surrounding (about 10 m area on all sides) were clipped to prevent anemophily. It was observed that all the flowers developed normal achenes indicating successful entomophily. Small flies are seen as the most frequent flower visitors, resting on the bowl-shaped flowers for long durations.

Similar observations have also been recorded for *Ranunculus adoneus* in Colorado Rockies of USA and the significance of sun-tracking for more efficient pollination and seed setting has been proved (Stanton and Galen, 1989). Hocking and Sharplin (1965) discovered flower basking by insects in arctic *Dryas integrifolia* and *Papaver radicatum* and have suggested that in an environment where the season is short and every calorie counts, it must have survival value in

Time	I	Day	II	Day	III	Day	IV	Day	V	Day	VI	Day	VII	Day
	S	R	S	R	S	R	S	R	S	R	S	R	S	R
0008 hrs	78	72	60	90	66	84	69	81	73	77	80	70	71	79
1200 hrs	133	17	125	25	137	14	128	22	138	12	124	26	129	21
2000hrs	16	134	13	137	20	130	12	142	23	127	18	132	22	128
00 hrs	8	142	9	141	12	128	13	137	15	135	18	132	20	130

S = sun facing (when sun is available i.e. 0008 hrs to 1300hrs) or sky facing (when sun is not available).
R = randomly oriented (not facing sun when sun is available, i.e. 0008 hrs to 1300 hrs) or pendent (when sun is not available).

accelerating the ripening of the insect germ cells. Kevan has also indicated that the extra warmth obtained by the basking insect due to heliotropic movement of flowers must be valuable in increasing the insects' metabolism, giving them greater mobility by preheating them for flight, thus increasing their abilities of pollination (Kevan, 1975). Similar significance could not be ruled out in case of *Ranunculus hirtellus*. Heliotropism has been considered as an adaptive feature of arctic and alpine plants and its could also be an adaptive feature in alpine plants of the Himalaya having bowl shaped flowers.

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